

MANUFACTURING FACILITY AND METHOD OF ASSEMBLING
TEMPERATURE CONTROLLED RAILWAY CAR

RELATED APPLICATION

This application claims the benefit of provisional application entitled, "Temperature Controlled Railway Car", Serial No. 60/267,882 filed February 9, 2001.

5 This application is related to copending patent application entitled, "Pultruded Panel", Serial No. _____, filed _____; copending patent application entitled, "Roof Assembly and Airflow Management System For A Temperature Controlled Railway Car", Serial No. _____, filed _____; and copending application
10 entitled, "Temperature Controlled Railway Car", Serial No. _____, filed _____ which claim priority from the same provisional application.

15 TECHNICAL FIELD

 The present invention is related to a manufacturing facility and method of assembling a railway car and more particularly forming components of a composite box structure and attaching the components to a railway car
20 underframe.

BACKGROUND OF THE INVENTION

Over the years, general purpose railway boxcars have progressed from relatively simple wooden structures mounted on flat cars to more elaborate arrangements including insulated walls and refrigeration equipment. Various types of insulated boxcars are presently manufactured and used. A typical insulated boxcar includes an enclosed structure mounted on a railway car underframe. The enclosed structure generally includes a floor assembly, a pair of side walls, a pair of end walls and a roof. The side walls, end walls and roof often have an outer shell, one or more layers of insulation and interior paneling.

The outer shell of many railway boxcars often has an exterior surface formed from various types of metal such as steel or aluminum. The interior paneling is often formed from wood and/or metal as desired for the specific application. For some applications the interior paneling has been formed from fiber reinforced plastic (FRP). Various types of sliding doors including plug type doors are generally provided on each side of conventional boxcars for loading and unloading freight. Conventional boxcars may be assembled from various pieces of wood, steel and/or sheets of composite materials such as fiberglass reinforced plastic. Significant amounts of raw material, labor and time are often required to complete the manufacture and assembly of conventional boxcars.

The underframe for many boxcars include a center sill with a pair of end sill assemblies and a pair of

side sill assemblies arranged in a generally rectangular configuration corresponding approximately with dimensions for the floor of the boxcar. Cross bearers are provided to establish desired rigidity and strength for

5 transmission of vertical loads to the associated side sills which in turn transmit the vertical loads to the associated body bolsters and for distributing horizontal end loads on the center sill to other portions of the underframe. Cross bearers and cross ties cooperate with

10 each other to support a plurality of longitudinal stringers. The longitudinal stringers are often provided on each side of the center sill to support the floor of a boxcar. Examples of such railway car underframes are shown in United States Patent Nos. 2,783,718 and

15 3,266,441.

Some railway cars or boxcars may be manufactured using side wall assemblies with all or portions of a respective side sill assembly formed as an integral component thereof. In a similar manner, such railway

20 cars and/or boxcars may also be manufactured with end wall assemblies having all or portions of a respective end sill formed as an integral component thereof.

Traditionally, refrigerated boxcars often have less inside height than desired for many types of lading and a

25 relatively short interior length. Heat transfer rates for conventional insulated boxcars and refrigerated boxcars are often much greater than desired. Therefore, refrigeration systems associated with such boxcars must be relatively large to maintain desired temperatures

30 while shipping perishable lading.

A wide variety of composite materials have been used to form railway cars and particular boxcars. U.S. Patent No. 6,092,472 entitled "Composite Box Structure For A Railway Car" and U.S. Patent No. 6,138,580 entitled
5 "Temperature Controlled Composite Boxcar" show some examples. One example of a composite roof for a railway car is shown in U.S. Patent No. 5,988,074 entitled "Composite Roof for a Railway Car".

Ballistic resistant fabrics such as Bulitex scuff
10 and wall liners have previously been used to form liners for highway truck trailers.

SUMMARY OF THE INVENTION

In accordance with teachings of the present invention, several disadvantages and problems associated with manufacture and assembly of insulated boxcars, refrigerated boxcars and other types of temperature controlled railway cars have been substantially reduced or eliminated. One embodiment of the present invention includes a composite box structure with a temperature control system and an airflow management system satisfactory for use with a refrigerated boxcar or a temperature controlled railway car. Another embodiment of the present invention includes a composite box structure which may be satisfactory for use with an insulated boxcar.

A composite box structure formed in accordance with teachings of the present invention combines the benefits conventional railway car components with the benefits of advanced plastic and composite materials. For one application a temperature controlled railway car may be formed in accordance with teachings with the present invention with enlarged interior dimensions of approximately seventy two feet, two inches inside length, nine feet, two inches inside width and an inside height at the center line of twelve feet, one and one half inches. A composite box structure formed in accordance with teachings of the present invention provides enhanced insulation, increased load carrying capacity, better temperature regulation, increased service life, and reduced maintenance costs as compared to a typical refrigerated boxcar.

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The present invention allows designing side wall assemblies and end wall assemblies with insulating materials having optimum thickness to substantially minimize heat transfer rates between the interior and the exterior of a resulting composite box structure and to maximize interior load carrying capacity. Structural integrity of a resulting composite box structure may be maintained using conventional materials such as steel alloys to form exterior portions of the side wall assemblies and end wall assemblies.

A railway car may be formed in accordance with teachings of the present invention with similar or reduced costs as compared to conventional refrigerated boxcars and insulated boxcars with substantially improved load carrying capacity and thermal energy characteristics. Many structural members of the resulting railway car may be formed from steel alloys and other materials which may be easily repaired as compared with some composite materials. Composite materials with substantially improved insulation characteristics are used as nonstructural members to improve heat transfer characteristics while at the same time increasing load carrying capability.

Technical benefits of the present invention include relatively flexible joints or flexible connections between side wall assemblies and the end assemblies to allow limited movement of these components relative to each other. Flexible joints or flexible connections may also be provided to allow expansion and contraction of a roof assembly and/or floor assembly relative to other

components in response to temperature changes while maintaining desired structural integrity of an associated composite box structure.

One aspect of the present invention includes
5 forming side wall assemblies and end wall assemblies defined in part by a plurality of support posts or end beams with metal side sheets attached to one side of the support posts or end beams and at least one layer of ballistic resistant fabric attached to the opposite side
10 of the support posts or end beams with void spaces formed therebetween.

Fabricating side wall assemblies and end wall assemblies with respective side sill assembly and end sill assembly in accordance with teachings of the present
15 invention allows optimizing associated fabrication techniques and reduces both cost and time required to complete manufacture and assembly of the resulting temperature controlled railway car or insulated boxcar. Various benefits associated with fabricating side wall
20 assemblies and end wall assemblies in accordance with teachings of the present invention will be discussed throughout this patent application.

BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of the present invention, and the advantages thereof, reference is now
5 made to the following written description taken in conjunction with the accompanying drawings, in which:

FIGURE 1A is a schematic drawing in elevation showing a side view of a temperature controlled railway car having a composite box structure with a temperature
10 control system and an airflow management system incorporating teachings of the present invention;

FIGURE 1B is an end view of the temperature controlled railway car of FIGURE 1A;

FIGURE 2 is a schematic drawing in section with
15 portions broken away taken along lines 2-2 of FIGURE 1A showing portions of a side wall assembly incorporating teachings of the present invention;

FIGURE 3 is a schematic drawing showing a plan view of one example of a railway car underframe satisfactory
20 for use in forming a temperature controlled railway car in accordance with teachings of the present invention;

FIGURE 4 is a schematic drawing showing a side view of the railway car underframe of FIGURE 3;

FIGURE 5 is a schematic drawing in elevation showing
25 the railway car of FIGURE 1A prior to attaching safety appliances and an end platform;

FIGURE 6 is a schematic drawing in elevation with portion broken away, taken along lines 6-6 of FIGURE 5, showing one example of metal sheets attached with an

exterior surface of an end wall assembly in accordance with teachings of the present invention;

FIGURE 7A is a schematic drawing in section with portions broken away showing selected features of end wall assemblies forming portions of a composite box structure mounted on a railway car underframe incorporating teachings of the present invention;

FIGURE 7B is a drawing in section showing one example of a side sill assembly formed in accordance with teachings of the present invention;

FIGURE 8 is a schematic drawing showing a cross section taken along lines 8-8 of FIGURE 5;

FIGURE 9 is a schematic drawing in section taken along lines 9-9 of FIGURE 5;

FIGURE 10 is a schematic drawing in section taken along lines 10-10 of FIGURE 5;

FIGURE 11 is a block diagram showing one example of a method for assembling a temperature control railway car in accordance with teachings of the present invention;

FIGURE 12 is a block diagram showing one example of a method for assembling a railway car underframe such as shown in FIGURES 3 and 4;

FIGURE 13 is a block diagram showing one example of a method for assembling a side wall assembly in accordance with teachings of the present invention;

FIGURE 14 is a block diagram showing one example of a method for assembling an end wall assembly in accordance with teachings of the present invention;

FIGURE 15 is a schematic drawing showing an end view of a foam press which may be satisfactorily used to bond

liquid insulating foam with portions of a side wall assembly or an end wall assembly to form solid foam insulation in accordance with teachings of the present invention;

5 FIGURE 16 is a schematic drawing showing a plan view of one example of a manufacturing facility which may be satisfactorily used to manufacture and assemble a temperature controlled railway car or an insulated boxcar in accordance with teachings of the present invention;

10 FIGURE 17 is a schematic drawing showing an isometric view of one example of a panel satisfactory for use in forming portions of a floor assembly for the temperature controlled railway car of FIGURES 1A and 1B;

15 FIGURE 18 is a schematic drawing showing an end view of the pultruded panel of FIGURE 17;

FIGURE 19 is a schematic drawing in elevation with portions broken away showing a side wall frame assembly incorporating teachings of the present invention; and

20 FIGURE 20 is a schematic drawing in elevation with portions broken away showing an end wall frame assembly incorporating teachings of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Preferred embodiments of the invention and its advantages are best understood by reference to FIGURES 1A-20 of the drawings, like numerals are used for like and corresponding parts of the various drawings.

Various aspects of the present invention will be described with respect to temperature control railway car 20. However, the present invention is not limited to temperature controlled railway cars. For example, various features of the present invention may be satisfactory used to form insulated boxcars and other types of freight cars or railway cars having side wall assemblies and end wall assemblies mounted on a railway car underframe.

Temperature controlled railway car 20 incorporating teachings of the present invention is shown in FIGURES 1A, 1B and 5 with composite box structure 30 mounted on railway car underframe 200. As discussed later in more detail, temperature controlled railway car 20 may include temperature control system 140 and airflow management system 300.

For embodiments of the present invention as shown in FIGURES 1A-10, temperature controlled railway car 20 may have exterior dimensions which satisfy requirements of Plate F and associated structural design requirements of the Association of American Railroads (AAR). Forming various components of composite box structure 30 in accordance with teachings of the present inventions and assembling these components on railway car underframe 200 results in reducing the weight of temperature controlled

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teachings of the present invention will be discussed throughout this application.

The term "support post" may be used to refer to side posts, side stakes or other structural components
5 satisfactory for use in forming a side wall assembly incorporating teachings of the present invention.

The term "end beam" may be used to refer to I beams or other structural components satisfactory for use in forming an end wall assembly incorporating teachings of
10 the present invention. For some applications support posts and end beams may be formed from metal I beams having similar cross sections.

The term "FRP" may be used to refer to both fiber reinforced plastic and glass fiber reinforced plastic. A
15 wide variety of fibers in addition to glass fibers may be satisfactorily used to form portions of a composite box structure incorporating teachings of the present invention.

Composite box structure 30 may be formed from
20 several major components including roof assembly 40, side wall assemblies 50 and 52, floor assembly 80 and end wall assemblies 120 and 122. Major components associated with composite box structure 30 are preferably fabricated individually in accordance with teachings of the present
25 invention and then attached to or assembled on railway car underframe 200 to form temperature controlled railway car 20. Individually manufacturing or fabricating major components of composite box structure 30 allows optimum use of conventional railcar manufacturing techniques.
30 For example, side posts and door posts may be welded with

top chords and side sill assemblies using conventional railcar manufacturing techniques to provide structural members for a side wall assembly.

Manufacturing procedures associated with
5 thermoplastic materials and insulating foam may be modified in accordance with teachings of the present invention to form other portions of composite box structure 30. For example, side wall assemblies and end wall assemblies filled with foam insulation may be used
10 to form portions of a composite box structure with substantially improved heat transfer characteristics as compared with conventional refrigerated boxcar floor assemblies.

Side wall assemblies 50 and 52 and end wall
15 assemblies 120 and 122 may be formed using substantially similar techniques to form an exterior metal surface and an interior surface of fiber reinforced material with foam insulation bonded therebetween. FIGURE 2 shows a typical cross section for side wall assembly 50. Since
20 side wall assemblies 50 and 52 have substantially the same configuration and overall design, various features of the present invention will be discussed primarily with respect to side wall assembly 50.

For the embodiment of the present invention
25 represented by composite box structure 30, side wall assembly 50 preferably includes a plurality of metal side sheets 54 disposed on the exterior of composite box structure 30. Each side sheet 54 preferably includes an exterior surface 53 and an interior surface 55. Exterior
30 surfaces 53 of side sheets 54 cooperate with each other

to form an exterior metal surface for side wall assembly 50 and composite box structure 30.

A plurality of support posts 56 are preferably attached to interior surface 55 of each side sheet 54 spaced from each other and extending inwardly towards interior 32 of composite box structure 30. Each support post 56 may include exterior surface 59 attached with adjacent portions of interior surface 55 of respective side sheet 54. For some applications isolators 60 may be attached with interior surface or first surface 57 of each support post 56.

For some applications isolators 60 may be formed from thermoplastic polymers such as polyvinyl chloride (PVC). Various other types of thermoplastic materials and other insulating materials may be satisfactorily used to form isolators 60 attached with interior surface or second surface 59 of each support post 56. The present invention is not limited to PVC type materials.

Isolators 60 may have various configurations. For example, isolators 60 may be a strip of thermoplastic material extending along substantially the full length of the associated support post 56. Alternatively, isolators 60 may be formed from blocks of PVC material with alternating blocks (not expressly shown) of insulating foam disposed therebetween and attached to interior surface 57 of support posts 56. Attaching isolators 60 with interior surface 57 of support posts 56 substantially reduces heat transfer between associated support posts 56 and interior 32 of composite box structure 30. Alternating blocks of PVC material with

blocks of insulating foam may provide even greater reductions in heat transfer rates between associated support posts 56 and interior 32 of composite box structure 30.

5 At least one layer of fiber reinforced material is preferably disposed on isolators 60 to form an interior surface of side wall assembly 50 and the associated composite box structure 30. For the embodiment of the present invention as shown in FIGURE 2 side wall assembly
10 50 includes both first layer 61 of fiber reinforced material and second layer 62 of fiber reinforced material. A plurality of void spaces 63 may be formed between first layer 61 and second layer 62 of fiber reinforced material. Various types of adhesives and/or
15 mechanical fasteners may be used to attach second layer 62 with first layer 61. For some applications second layer 62 may be nailed to first layer 61 by nails (not expressly shown) inserted into isolators 60.

Foam insulation 58 is preferably disposed between
20 and bonded with adjacent portions of interior surface 55 of metal sheets 54, adjacent portions of support posts 56 and adjacent portions of fiber reinforced material 61. For some applications a layer of scrim (not expressly shown) may be attached to the interior of first layer 61
25 to enhance bonding with foam insulation 58. The scrim layer may be formed from nonwoven fabric or any other suitable material for bonding with foam insulation 58.

Second layer 62 preferably includes a corrugated cross section which provides desired airflow paths 63
30 when lading is disposed adjacent to the interior surface

of side wall assembly 50. The corrugated cross section of second layer 62 provides airflow paths which form a portion of airflow management system 300.

First layer 61 and second layer 62 are preferably
5 formed from tough, light weight, rigid material having high impact resistance. Various polymeric materials may be used to form first layer 61 and second layer 62. For some applications only first layer 61 may be attached to a side wall assembly. For other applications, the
10 thickness of second layer 62 may be increased and applies directly to isolators 60 without first layer 61. First layer 61 and second layer 62 are preferably formed from Bulitex material available from U.S. Liner Company, a division of American Made, Inc. Bulitex material may be
15 generally described as a ballistic grade composite scuff and wall liner.

Various types of ballistic resistant fabric may also be satisfactorily used to provide a liner for a composite box structure in accordance with teachings of the present
20 invention. Ballistic resistant fabrics are often formed with multiple layers of woven or knitted fibers. The fibers are preferably impregnated with low modulus elastomeric material as compared to the fibers which preferably have a high modulus. U.S. Patent 5,677,029
25 entitled "Ballistic Resistant Fabric Articles" and assigned to Allied Signal shows one example of a ballistic resistant fabric.

For one application side sheet 54 may be formed from twelve (12) gauge steel. Support post 56 may be three
30 (3) inch I-beams. Isolators 60 may have dimensions of

approximately two (2) inches by two (2) inches by three-fourths (3/4) of an inch. Foam insulation 58 may have a thickness of approximately four (4) inches. First layer 61 may be formed from Bulitex material having a thickness
5 of approximately 0.06 inches. Second layer 62 may be formed from Bulitex material having a thickness of approximately 0.04 inches. The width of corrugations formed in second layer 62 may be between approximately four (4) and five (5) inches. The corrugations
10 preferably formed airflow gaps 63 of approximately one-half (1/2) inch relative to first layer 61.

For embodiments of the present invention as shown in FIGURES 3 and 4 portions of railway car underframe 200 may be manufactured and assembled using conventional
15 railcar manufacturing procedures and techniques. Railway car underframe 200 includes a pair of railway car trucks, 202 and 204, located adjacent to each end of railway car underframe 200. Standard railcar couplings 210 are also provided at each end of railway car underframe 200. Each
20 coupling 210 preferably includes end of car cushioning unit 212 disposed between each end of center sill 214 and the respective coupling 210. Railway car underframe 200 preferably includes a plurality of longitudinal stringers 230. FIGURES 7A, 8 and 9 show portions of floor assembly
25 80 disposed on longitudinal stringers 230 and attached to railway car underframe 200.

Railway car underframe 200 includes a pair of body bolsters 224 and 226 disposed over respective railway trucks 202 and 204. Body bolsters 224 and 226 extend
30 laterally from center sill 214. For the embodiment shown

in FIGURE 3, each body bolster 224 and 226 includes cover plates 228 which extend over the wheels of railway car underframe 202 and 204. Cover plates 228 reinforce openings created in railway car underframe 200 to provide
5 required wheel clearance for railway car or trucks 202 and 204.

Railway car underframe 200 includes center sill 214, longitudinal stringers 230, cross bearers 217, cross ties 216 and body bolsters 222 and 224 arranged in a generally
10 rectangular configuration. Cross bearers 217 and cross ties 216 are attached to and extend laterally from center sill 214. Longitudinal stringers 230 are preferably spaced from each other extending parallel with center
15 sill 214. The number of cross bearers, cross ties and longitudinal stringers may be varied depending upon desired load carrying characteristics for the resulting insulated boxcar or temperature controlled railway car.

Each longitudinal stringer 230 preferably includes first surface 231 and second surface 232 which rests upon
20 cross bearers 217 and cross ties 216. A portion of floor assembly 80 may be adhesively bonded or securely attached (not expressly shown) with portions of first surfaces 231 of longitudinal stringers 230. Other portions of floor assembly 80 may expand and contract relative to
25 longitudinal stringers 230.

A typical railway car underframe includes a pair of side sill assemblies and a pair of end sill assemblies which cooperate with each other to define a generally elongated, rectangular configuration or perimeter for the
30 associated railway car. In accordance with teachings of

the present invention, side wall assemblies 50 and 52 are preferably fabricated with respective side sill assemblies 250 and 252 formed as an integral component thereof. End wall assemblies 120 and 122 are also
5 preferably fabricated with at least portions of respective end sill assemblies 220 and 222 formed as integral components thereof.

As previously noted, roof assembly 40, side wall assemblies 50 and 52, floor assembly 80, and end wall
10 assemblies 120 and 122 are preferably fabricated as individual components. Roof assembly 40 may be formed as a vacuum molded, single pour, one piece, glass fiber panel. Alternatively, roof assembly 40 may be formed from one or more pultrusions. Void spaces associated
15 with such pultrusions are preferably filled with an insulating foam. Each component may then be attached to railway car underframe 200 in accordance with teachings of the present invention.

Roof assembly 40 may be formed with a generally
20 elongated, rectangular configuration. The length and width of roof assembly 40 corresponds generally with the desired length and width of composite box structure 30. Roof assembly 40 includes first longitudinal edge 41 and second longitudinal edge 42 spaced from each other and
25 extending generally parallel with each other from first lateral edge 43 to second lateral edge 44. Roof assembly 40 may have a generally arcuate configuration extending from first longitudinal edge 41 to second longitudinal edge 42. See FIGURES 5, 6 and 7a. First longitudinal
30 edge 41 and second longitudinal edge 42 are preferably

mounted on and attached with adjacent portions of
respective side wall assemblies 50 and 52. Lateral edges
43 and 44 are preferably mounted on and attached with
respective end wall assemblies 120 and 122. See FIGURE
5 7a.

Various types of composite materials and insulating
materials may be satisfactory used to form roof assembly
40. For some applications roof assembly 40 may be formed
from one or more FRP layers 45 and 46. As shown in
10 FIGURE 7a FRP layer 45 provides outer surface 38 of roof
assembly 40. FRP layer 46 provides interior surface 39
of roof assembly 40. FRP layers 45 and 46 may be bonded
with each other to encapsulate insulating layer 47
therebetween. A wide variety of materials having desired
15 thermal insulating characteristics may be satisfactorily
used to form insulating layer 47. A plurality of "Z-
shaped stiffeners" 48 are preferably disposed within roof
assembly 40 extending from first longitudinal edge 41 to
second longitudinal edge 42.

20 Each end wall assembly 120 and 122 preferably
includes a respective top chord or top plate 130 attached
with upper portions of adjacent metal sheets 54. Roof
assembly 40 may be attached to and bonded with respective
top chord 64 of side wall assemblies 50 and 52, and top
25 chords or top plates 130 of end wall assemblies 120 and
122. As shown in FIGURE 7a, insulating foam is
preferably disposed within the joints or flexible
connections formed between roof assembly 40 and adjacent
portions of end wall assemblies 120 and 122.

For one embodiment side wall assembly 50 is preferably mounted on one side of railway car underframe 200 with side sill assembly or bottom chord 250 disposed adjacent to the first ends 217a of cross bearers 217 and
5 first ends 216a of cross ties 216. In a similar manner side wall assembly 52 is preferably mounted on an opposite side of railway car underframe 200 with side sill assembly or bottom chord 252 disposed adjacent to first ends 217b of cross bearers 217 and first end 216b
10 of cross ties 216.

As previously noted, side sill assemblies 250 and 252 have approximately the same overall dimensions and configuration. Therefore, only side sill assembly 250 as shown in FIGURE 7B will be discussed and described in
15 detail. Side sill assembly 250 has a generally J shaped cross section. The configuration of exterior surface 254 of side sill assembly 250 preferably corresponds with the dimensions of plate F. Supporting member 256 is preferably attached to interior surface 258 of side sill
20 assembly 250. Supporting member 256 provides support for primary floor 100.

A metal angle is preferably attached with interior surface 258 of side sill assembly 250 to provide respective supporting member 256.

25 Various types of mechanical fasteners and/or welding techniques may be used to attach side sill assemblies 250 and 252 and the respective ends of cross bearers 217 and cross ties 216. For some applications Huck type mechanical fasteners are preferably used to attach side

sill assemblies 250 and 252 with the respective cross bearers 217 and/or cross ties 216.

For some applications a plurality of pultruded panels 82 are preferably bonded with each other to form
5 primary floor 100 having a generally rectangular configuration corresponding with the desired interior length and width for composite box structure 30. The length of each pultruded panel 82 preferably corresponds with the approximate desired interior width of composite
10 box structure 30. The number of pultruded panels 82 used to form primary floor 100 is approximately to the desired interior length of composite box structure 30 divided by the width of pultruded panel 82. For some applications one or more pultruded panels with a narrower width than
15 pultruded panels 82 may be used to form primary floor 100 with the desired overall length. Primary floor 100 may then be attached to railway car underframe 200.

FIGURES 9 and 10 are schematic drawings showing various features of the present invention. For example,
20 side wall assembly 50 is shown with its associated door assembly 180 in its first, closed position blocking access through associated opening 36. Side wall assembly 52 is shown without door assembly 180 which allows access to interior 32 through the associated opening 36.
25 Interior bulkhead 280, which forms a portion of the associated airflow management system 300, is shown in FIGURE 10 disposed adjacent to the interior surface of side wall assembly 120.

FIGURE 9 shows one example of restraining anchors
30 assemblies 270 which may be formed between portions of

primary floor 100 and portions of selected longitudinal stringers 230 near opposite ends of railway car underframe 200. For some applications selected portions of primary floor 100 may be adhesively bonded or securely
5 attached with adjacent portions of railway car underframe 200. Other portions of primary floor 100 which are not bonded with railway car underframe 200 may expand and contract relative to longitudinal stringers 230 as temperature changes occur within composite box 30. For
10 some applications restraining anchor assemblies 270 may be attached with adjacent portions of primary floor 100 and longitudinal stringers 230 to allow limited longitudinal movement of floor assembly 80 relative to railway car underframe 200 and substantially restrict
15 vertical movement of floor assembly 80 relative to railway car underframe 200 during thermal expansion and contraction.

Temperature control system 140 preferably includes refrigeration unit or cooling unit 142 and airflow
20 management system 300 which provides uniform, constant airflow around and through lading carried within composite box structure 30. For some applications such as transporting products in sub-zero, winter environments temperature control system 140 may include a heater.

25 Refrigeration unit 142 may be a self-contained refrigeration unit including a compressor (not expressly shown), a condenser (not expressly shown), airflow blowers (not expressly shown), an external fuel tank 219 and a diesel engine (not expressly shown). For some
30 applications, refrigeration unit 142 may provide airflow

in the range of 3200 CFM. Self-contained refrigeration unit 142 provides advantages of easier and faster maintenance as compared to conventional refrigerated boxcars with similar performance characteristics. As a
5 result, temperature control system 140 generally lowers maintenance time and costs and increases the amount of time that temperature controlled railway car 20 remains in service between repairs.

Refrigeration unit 142 may be a programmable unit
10 able to control and maintain desired temperatures within composite box structure 30. Refrigeration unit 142 may include a keypad for inputting data for desired system performance and a microprocessor to control and monitor the functions and performance of refrigeration unit 142
15 and temperature control system 140. Refrigeration unit 142 may also include a satellite monitoring and control system (not expressly shown) and/or cellular technology to transmit to remote locations information such as the performance and location of refrigeration unit 142 or the
20 temperature inside composite box structure 30. Various types of refrigeration systems are commercially available from companies such as Thermo King, Carrier and Dring. Such units are frequently used in motor carrier trailers and other large containers.

As shown in FIGURES 1A and 1B, refrigeration unit
25 142 may be mounted on end wall assembly 120 of the composite box structure 30. End platform system 260 may be coupled to railway car underframe 200 near refrigeration unit 142 to provide easy access to
30 refrigeration unit 142. Alternatively, refrigeration unit

142 may be mounted on a secondary end wall or bulkhead (not shown expressly) located within composite box structure 30 to provide better protection for refrigeration unit 142. Refrigeration unit 142 may
5 include an external fuel tank 219 which may be located proximate to refrigeration unit 142. See FIGURE 5. This provides the benefit of convenient access to both fuel tank 219 and refrigeration unit 142.

FIGURES 11-14 are block diagrams which show various
10 steps of forming a temperature controlled railway car or an insulated boxcar in accordance with teachings of the present invention. The sequence of steps shown in FIGURE 11 - method 500, FIGURE 12 - method 560, FIGURE 13 - method 570, or FIGURE 14 - method 590 may be varied as
15 desired for a specific manufacturing facility or railway car design.

For some applications, all of the steps associated with method 500 may be carried out at the same manufacturing facility. For other applications, one or
20 more of the steps associated with method 500 may be carried out at one or more remotely located facilities. One of the benefits of the present invention includes optimizing the manufacture and assembly of components associated with a composite box structure.

25 In FIGURE 11 method 500 for forming a temperature controlled railway car such as previously described railway car 20 starts with the assembly of railway car underframe 200 at step 520. Other steps associated with assembling railway car underframe 200 will be discussed
30 with respect to FIGURE 12.

Side wall assemblies 50 and 52 may be prepared at step 570. Additional steps associated with preparation of side wall assemblies 50 and 52 are shown in FIGURE 13. At step 522 side wall assemblies 50 and 52 may be
5 attached with opposite sides of railway car underframe 200.

Primary floor 100 may be prepared for bonding at step 590. At step 524, various components associated with primary floor 100 are applied to and bonded with
10 portions of railway car underframe 200.

End wall assemblies 120 and 122 are prepared at step 605. Additional steps associated with manufacturer and assembly of end wall assemblies 120 and 122 are shown in FIGURE 14. At steps 526 end wall assemblies 120 and 122
15 are mounted on and attached to opposite ends of railway car underframe 200. At step 528 any remaining weld out required for railway car underframe 200 and attachment of side wall assemblies 50 and 52 with end wall assemblies 120 and 122 may be completed at step 528.

Roof assembly 40 may be prepared at step 610. At step 530 roof assembly 40 is preferably attached with side wall assemblies 50 and 52 and end wall assemblies 120 and 122 opposite from floor assembly 80 and railway car underframe 200.
20

Flexible joints and corner joints formed between adjacent portions of side wall assemblies 50, 52, end wall assemblies 120, 122, roof assembly 40 and floor assembly 80 are preferably filled with insulating foam and covered with trim molding at step 534. For some
25 applications blocks of polyurethane foam or blocks of
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other suitable insulating material may be installed in the joints. Additional liquid insulating foam may then be injected into the joints to complete filling each joint with desired insulating foam. For other

5 applications one or more joints may be filled with only liquid insulating foam to provide the desired resulting foam insulation.

For some applications, as shown in FIGURE 7a, one or more rows of sealant 248 may be disposed between the ends
10 of primary floor 100 and adjacent portions of end wall assemblies 120 and 122. One or more layers of insulating foam 246 may also be applied over sealant 248.

Respective trim molding 75 may then be attached on and bonded with adjacent portions of end wall assemblies 120
15 and 122 and primary floor 100. Similar trim molding 74 may be attached with adjacent portions of roof assembly 40 and end wall assemblies 120 and 122. Flexible connections and/or joints formed between primary floor 100 and adjacent portions of side wall assemblies 50 and
20 52, and connections between roof assembly 40 and side wall assemblies 50 and 52 may also be filled with similar sealants and foam insulation.

Respective doors 180 are slidably mounted adjacent to opening 36 in each side wall assembly 50 and 52 at
25 step 536. Various types of safety equipment such as ladders and brake systems may be attached with composite box structure 30 at step 538. Exterior portions of composite box structure 30 may be painted at step 540. Secondary floor 110 may be placed on and bonded with
30 primary floor 100, refrigeration unit 142 attached with

the exterior of end wall assembly 120, and interior bulkhead 280 formed within railway car underframe spaced from end wall assembly 120 at step 542. Final inspection of temperature controlled railway car 120 and correction
5 of any further assembly procedures may be completed at step 544.

As shown in FIGURE 12 assembly of railway car underframe 200 includes various steps such as assembling center sill 214 at step 562. Respective body bolsters
10 may be attached with center sill 214 at step 564. First railway truck 202 may be attached proximate to the first end of center sill 214. Second railway truck 204 may be attached to the second end of center sill 214 proximate to the second end center sill 214 at step 566. At step
15 568 a plurality of cross bearers 217 and cross ties 216 may be attached on both sides of center sill 214. A plurality of longitudinal stringers 230 are then placed on cross bearers 217 and cross ties 216 spaced from each other and extending generally parallel with center sill
20 214. At step 569 assembly of other components associated with railway car underframe 200 may be completed.

As shown in FIGURE 13, fabricating a side wall assembly includes various steps such as preparing support posts or side stakes at step 571, preparing a door frame
25 assembly at step 572, preparing a side sill assembly at step 573 and preparing a top chord at step 574. A side wall frame assembly such as shown in FIGURE 19 may be prepared at step 575 by attaching support posts 56 with top chord 64 and side sill assembly 250 as previously
30 described. The associated door frame assembly may also

be attached with top chord 64 and side sill assembly 250 at the desired location for opening 36.

At step 576, a plurality of metal sheets or side sheets 54 may be placed on the exterior of side wall frame assembly 51. At step 577 metal sheets 54 may be welded with the adjacent portions of side wall frame assembly 51. At step 578 side wall frame assembly 51 may be cleaned. At step 579 isolators 60 are preferably placed on interior surfaces 57 of the support posts 56. Layers 61 of fiber reinforced plastic may also be placed on isolators 60 at step 579. At step 580 the side wall assembly may be preheated. At step 581 the side wall assembly may be placed in a foam press such as shown in FIGURE 15 and liquid insulating foam injected into void spaces formed between metal sheets 54, adjacent portions of support posts 56 and the interior surface of the layers 61 of fiber reinforced plastic.

As shown in FIGURE 14, fabrication of an end wall assembly includes various steps such as preparing end beam 126 at step 591. Top plate 130 may be prepared at step 592. At least a portion of an end sill assembly such as angle 221 may be prepared at step 593. At step 594 end beams 126 may be attached with first edge plate 129 and second edge plate 131 to form a generally rectangular configuration. Top plate 130 may then be attached adjacent to one end of edge plates 129 and 131. The portion of the end sill assembly may be attached with opposite ends of edge plates 129 and 131 to form end frame assembly 121. See FIGURE 20.

For end wall assembly 120, step 594 may also be carried out, which includes forming a frame for an opening to accommodate an associated temperature control unit. At step 596 metal sheets 54 may be attached with
5 the exterior of end wall frame assembly 121. At step 597 metal sheets 54 may be welded to adjacent portions of end wall frame assembly 121. At step 598 isolators 60 may be attached with the interior surface of the end beams. At step 598, layers 61 of fiber reinforced plastic may also
10 be placed on isolators 60. At step 599 the end wall assembly is cleaned and preheated. At step 600 the end wall assembly is preferably placed in a foam press. See FIGURE 15. Liquid insulating foam may be injected through openings (not expressly shown) formed in edge
15 plate 129 or 131. The foam press will preferably provide sufficient heat to form solid foam insulation from the liquid insulating foam.

FIGURE 15 shows one example of a foam press satisfactory for use in forming a side wall assembly or
20 an end wall assembly in accordance with teachings of the present invention. As shown in FIGURE 15, foam press 698 may be tilted at an angle of approximately ten (10) degrees. For other applications the angle may be varied between eight (8) degrees and twelve (12) degrees. A
25 foam insulation press satisfactory for use in forming end wall assemblies and side wall assemblies in accordance with teachings of the present invention may be obtained from CON-TEK, Inc. located at 3575 Hoffman Road East, St. Paul, Minnesota.

One example of a manufacturing facility satisfactory in use in forming a temperature controlled railway car and/or an insulated boxcar in accordance with teachings of the present invention is shown in FIGURE 16.

5 Manufacturing facility 700 may include main building 702 and various support facilities such as component storage facility 704, floor material storage facility 706, sand blasting and paint shop 708, and safety appliance assembly facility 710. For embodiments of the present
10 invention as shown in FIGURE 16, main building 702 preferably includes assembly line 710 to form a railway car underframe, assembly line 720 to form a side wall frame assembly, assembly line 730 to form an end wall frame assembly, assembly line 740 to complete manufacture
15 of side wall assemblies and end wall assemblies and assembly line 750 for mounting side wall assemblies, end wall assemblies, a floor assembly and a roof assembly on the railway car underframe. Each assembly line 710, 720, 730, 740, and 750 include multiple working stations.

20 One or more of the assembly lines shown within building 702 may be located at a remote facility. For example, end wall assemblies 120 and 122, formed in accordance with teachings of the present invention may be manufactured at a remote facility (not expressly shown)
25 and shipped to another facility which includes assembly line 750 for mounting the end wall assemblies on a railway car underframe. Also, sand blasting and paint shop facility 708 and/or safety appliance shop 709 may be remotely located from each other and/or main building
30 702.

Various components required for manufacture and assembly of railway car underframe 200 may be stored within component storage facility 704. At first station 711, components may be moved from storage facility 704 to first station 711 to assemble center sill 214. At second station 712, additional components such as body bolsters 224 and 226 may be attached with center sill 214.

At third station 713, center sill 214 may also be prepared for later attachment of associated draft gear, cushioning units and railway car couplers. At third station 713, additional components such as cross bearers 217, cross ties 216 and portions of end sill assemblies 220 and 222, such as generally c-shaped channels 223, may also be attached with the railway car underframe. At fourth station 714, longitudinal stringers 230 and additional components may be applied with railway car underframe 200. At fifth station 715, temporary railway trucks may be attached with the railway car underframe. The railway car underframe may then be directed to sand blasting and paint shop 708. The resulting railway car underframe may then be directed towards assembly line 750 which will be discussed later in more detail.

Various components may be taken from storage facility 704 and moved to assembly line 720 for use in manufacturing side wall assemblies 50 and 52. At first station 721 side sill assembly or bottom chord 250 and 252 may be assembled. At second station 722 respective top chord 64 may be assembled. At third station 723 support posts 56 may be attached with respective top chord 64 and side sill assembly 250 or 252. At fourth

station 724, a plurality of metal sheets 54 may be welded with the exterior of side wall frame assembly 51. See FIGURE 19. At fifth station 725, isolators 60 and layers 61 of fiber reinforced material may be placed on support
5 posts 56 opposite from metal sheets 54.

Various components may also be taken from storage facility 704 and moved to assembly line 730 for use in manufacturing end wall assemblies 120 and 122. At first station 731, end beams 126, top plate 130 and angle 221
10 of end sill assembly 220 may be prepared for use in forming end wall frame assembly 121. See FIGURE 20. At second station 732, end wall frame assembly 121 may be formed from respective end beams 126, top plate 130, and angle 221. For end wall assemblies 120, a mounting frame
15 assembly may also be attached for use in installing temperature control unit 142. At third station 733, metal sheets 54 may be placed on the exterior of end wall frame assembly 121 and welded with adjacent portions thereof. At fourth station 734, isolators 60 may be
20 placed on end beams 126 opposite from metal sheets 54. Layer 61 of fiber reinforced material may then be placed on isolators 60.

Side wall assemblies 50 and 52 and end wall assemblies 120 and 122 may be directed to assembly line
25 740 for injection of liquid insulating foam in associated void spaces to form foam insulation 58. At first station 741, the side wall assemblies and end wall assemblies may be washed and cleaned in preparation for injecting liquid insulating foam. The side wall assemblies may be dried
30 at second station 742 and the end wall assemblies dried

at station 742a. At third station 743, isolator 60a may be bonded with support posts 56 and layer 61 of fiber reinforced material disposed thereon. Side wall assemblies 120 and 122 may then be preheated at four
5 stations 744a. End wall assemblies 120 may also be preheated at fourth station 74. A foam press, such as foam press 698 shown in FIGURE 15, is preferably provided at fifth station 745. Liquid insulating foam is preferably injected into respective void spaces in side
10 wall assemblies 50 and 522 and end wall assemblies 120 and 122. Foam press 698 provides required temperature control to form foam insulation 58 with bonds between interior surface 55 of side sheets 54, adjacent portions of support post 56 or end beams 126, and interior portion
15 of layer 61. At fifth station 745, the side wall assemblies and end wall assemblies are allowed to cool to complete the foaming and to complete the foam insulation process. At sixth station 746, final assembly of the side wall assemblies and end wall assemblies may be
20 completed.

Side wall assemblies 50 and 52 and end wall assemblies 120 and 122 may then be directed to assembly line 750. At first station 751, side wall assemblies 50 and 52 may be attached with railway car underframe 200.
25 At second station 752, primary floor 100 may be mounted on and attached with selected portions of railway car underframe 200. For example, a center portion of railway car underframe 200 may be securely bonded with adjacent portions of longitudinal stringers 230. Restraining
30 anchors 270 may be attached between other portions of

primary floor 100 and railway car underframe 230. See FIGURE 9. At third station 713 end wall assemblies may be attached with opposite ends of railway car underframe and side wall assemblies 50 and 52.

5 One or more roof assemblies may be stored at station 780. At station 781 each respective roof assemblies 40 may be prepared for mounting on a composite box structure in accordance with teachings of the present invention. At fourth station 715 a roof assembly 40 may be attached
10 with side wall assemblies 50 and 52 and end wall assemblies 120 and 122 opposite from railway car underframe. At fifth station 750 door assemblies 180 may be slightly attached with the exterior of each side wall assembly 50 and 52. At stations 753, 754 and/or 755
15 various flexible connections and corner joints may be foamed with insulation and trim molding applied thereto. From fifth station 755, the resulting railway car may be directed to safety appliance facility 709 for attachment of brakes and other equipment and sand blasting and paint
20 shop 708 to complete the manufacturing assembly of railway car 20.

As shown in FIGURES 17 and 18, each pultruded panel 82 may have a generally rectangular configuration defined in part by first end 81 and second end 83 with first
25 longitudinal edge profile 91 and second longitudinal edge profile 92 extending between first end 81 and second end 83. Longitudinal edge profiles 91 and 92 are spaced from each other.

Pultruded panel 82 may include first layer 84a and
30 second layer 84b with a plurality of webs or dividers 85

disposed therebetween. Webs 85a and 85c form a portion of respective first longitudinal edge profile 91 and second longitudinal edge profile 92. Webs 85 may have substantially the same dimensions. Void spaces or
5 cavities 86 formed in part by webs 85 may be filled with insulating foam (not expressly shown) having good thermal insulation characteristics. The use of insulating foam substantially reduces heat transfer through the resulting floor assembly 80.

10 The configuration of longitudinal edge profiles 91 and 92 are preferably selected to engage respective longitudinal edge profiles 91 and 92 of adjacent pultruded panels 82. Longitudinal edge profiles 91 and 92 may include respective flanges or lips 93 which extend
15 laterally therefrom along approximately the full length of the associated pultruded panel 82. Longitudinal edge profile 91 preferably includes recess 94 formed in first layer 84a. Longitudinal edge profile 92 preferably includes respective recess 94 formed in second layer 84b.
20 The dimensions and configurations of flanges 93 are selected to be compatible with recesses 94 of adjacent pultruded panels 82.

A projection such as bead 96 may be formed along longitudinal edge profile 91. When longitudinal edge
25 profile 91 is engaged with an adjacent longitudinal edge profile 92, bead 96 creates a gap therebetween to allow injection of an adhesive compound into the associated gap (not expressly shown). The adhesive compound (not expressly shown) may be used to bond or couple adjacent
30 pultruded panels with each other. Cover plates or end

caps 98 are shown placed over first end 81 and second end 83 to block access to associated void spaces 86. Cover plates 98 prevent moisture or other contaminants from contacting the associated insulating foam and reducing its thermal insulating characteristics. Also, any moisture or liquids which enter void spaces 86 may cause an undesired increase in the weight of the associated pultruded panel 82.

Portions of side wall frame assembly 51 satisfactory for use in forming a side wall assembly in accordance with teachings of the present invention are shown in FIGURE 19. For purposes of describing various features of the present invention side wall frame assembly 51 will be described with respect to forming side wall assembly 50. However, side wall frame assembly 51 may be used to form side wall assembly 52. Side wall frame assembly 51 includes a plurality of support posts 56, side sill assembly 250, top chord 64 and attached side sheets 54. Side wall frame assembly 51 may also include a door frame assembly (not expressly shown) required to mount door assembly 180 on side wall assembly 50.

First end 56a of each support post 56 is preferably attached to adjacent portions of top chord 64. Second end 56b of each support post 56 is preferably attached to adjacent portions of side sill assembly 250. Support posts 56, top chord assembly 64 and side sill assembly 250 cooperate with each other to define a generally elongated, rectangular configuration corresponding with side wall assembly 50. A plurality of metal sheets 54

are preferably attached with the exterior surface of side wall frame assembly 51.

Portions of end wall frame assembly 121 formed in accordance of teachings of the present invention are shown in FIGURE 20. For purposes of describing various features of the present invention, end wall frame assembly 121 will be described with respect to forming end wall assembly 120. However, end wall frame assembly 121 may be used to form end wall assembly 122. End wall frame assembly 121 includes top plate or top chord 130, angle 221 of end sill assembly 220 with edge plates 129 and 131 attached thereto and extending therebetween. A plurality of openings (not expressly shown) may be formed in edge plate 129 or 131 to allow injecting liquid insulating foam into adjacent void spaces.

First end 126a of each end beam 126 is preferably attached to edge plate 129. Second end 126b of each end beam 126 is preferably attached to respective portions of edge plate 131. End beams 126 are spaced from each other and extend generally parallel with top plate 130 and the associated angle 221. A plurality of metal sheets 54 may be attached with the exterior of end wall frame assembly 121.

Portions of side wall frame assembly 51 satisfactory for use in forming a side wall assembly in accordance with teachings of the present invention are shown in FIGURE 19. For purposes of describing various features of the present invention side wall frame assembly 51 will be described with respect to forming side wall assembly 50. However, side wall frame assembly 51 may be used to

form side wall assembly 52. Side wall frame assembly 51 includes a plurality of support posts 56, side sill assembly 250, top chord 64. Side wall frame assembly 51 also includes portions of a door frame assembly 180.

5 First end 56a of each support post 56 is preferably attached to adjacent portions of top chord 64. Second end 56b of each support post 56 is preferably attached to adjacent portions of side sill assembly 250. Support posts 56, top chord 64 and side sill assembly 250
10 cooperate with each other to define a generally elongated, rectangular configuration corresponding with side wall assembly 50. A plurality of metal sheets 54 are preferably attached with the exterior surface of side wall frame assembly 51.

15 Portions of end wall frame assembly 121 formed in accordance of teachings of the present invention are shown in FIGURE 20. For purposes of describing various features of the present invention, end wall frame assembly 121 will be described with respect to forming
20 end wall assembly 120. However, end wall frame assembly 121 may be used to form end wall assembly 122. End wall frame assembly 121 includes top plate or top chord 130, angle 221 with edge plates 129 and 131 attached thereto and extending therebetween. Top plate 130, angle 221,
25 and edge plates 129 and 131 form a generally rectangular configuration corresponding with end wall assembly 120 and 122.

A plurality of end beams 126 may also be attached with edge plates 129 and 131. First end 126a of each end
30 beam 126 is preferably attached to edge plate 129.

Second end 126b of each end beam 126 is preferably attached to respective portions of edge plate 131. End beams 126 are spaced from each other and extend generally parallel with top plate 130 and the associated angle 221.

- 5 A plurality of metal sheets 54 is preferably attached with the exterior of end wall frame assembly 121.

For some applications a plurality of openings (not expressly shown) may be formed in edge plates 129 and/or 131. The openings may be used to inject liquid
10 insulating foam into respective void spaces when end wall frame assembly 121 with isolators 60 and first layer 61 have been placed into a foam press. The number and size of the openings formed in edge plates 129 and/or 131 will depend upon the configuration and size of associated void
15 spaces formed adjacent to end beams 126.

One temperature controlled railway car formed in accordance with teachings of the present invention has the following features:

- 286,000 lb. Gross Rail Load;
- 20 Standard car equipped with 10'-0" wide by 11'- 3 1/2" high insulated single plug door 15" end-of-car cushioning unit;
- Meets AAR Plate "F" Clearance Diagram;
- State-of-the art temperature control unit,
- 25 exterior service platform and interior access door;
- Satellite monitoring and control system;
- An airflow management system installed in the interior of the composite box structure;
- 30 High performance insulating materials;

Durable, wood free interior materials; and
No ferrous metals in the interior.

Length Inside72'-2"
Length Over Coupler Pulling Faces82'-2"
5 Length over Strikers77'-10"
Length Between Truck Centers52'-0"
Truck Wheel Base5'-10"
Width, Extreme10'-6 5/8"
Width, Inside9'-2"
10 Height, Extreme16"-11 7/8"
Height Inside at Center Line of Car12'-1 1/2"
Estimated Lightweight105,000 lbs.
Estimated Load Limit -
Based on 286,000 lbs. Gross Rail Load181,000 lbs.
15 Gross Rail Load286,000 lbs.
Cubic Capacity (Between bulkheads)8,012 cubic feet
Cubic Capacity
(Level with height of sides)7,883 cubic feet

20 Although the present invention and its advantages
have been described in detail, it should be understood
that various changes, substitutions and alternations can
be made herein without departing from the spirit and
scope of the invention as defined by the following
25 claims.